Investigation of Best Practices in Water Utility Management Systems in the USA

by

Narongsak Thitithanyanont

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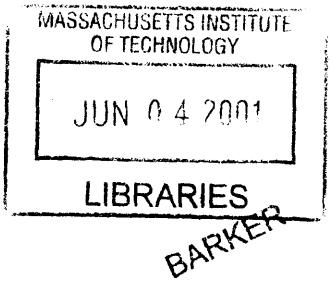

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ABSTRACT

Due to lack of competition in the water industry, water utilities have not experienced the rapid development seen in the electricity industry or the telecommunication industry. Some water utilities in the USA, however, have adopted practices that are accelerating their progress.

This thesis reports on the management practices of six water utilities, as well as on the management motivations to implement the practices. The documented practices include water resource planning and management, water conservation program, watershed protection programs, initiative concepts, wholesales contracts, and capital improvement programs. In my analysis of each of these practices, I investigated successful practices and factors contributing to their success, because these practices might be models for other utilities.

The thesis concludes with some findings; financial issues, water scarcity, or the introduction of new regulations in part led these water utilities to consider alternatives to their normal practices. Factors contributing to success, such as support from citizens or the state, long-term planned resource management, or efficient strategic business plan, vary among the utilities. In addition, commitment to the practices is a key to success. Although, these practices provide successful results in some cases, they might not be the most appropriate options for any particular situation. Further investigation of management systems will provide transparency to water authorities. This transparency will enable decision makers to elevate the standards of the water industry.

Thesis Supervisor: John B. Miller
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1 Introduction

1.1 Motivation

The arrival of the 21st century requires an improvement of productivity in every sector. Previously, water utilities tended to be unresponsive, inefficient, bureaucratic and monopolistic organizations. The authorities managed water utility to deliver what they thought their customers should receive from that service, rather than to provide from which the customers needed. Currently, several water utilities are being run in a businesslike manner and are responsive, as well as more open to the public[14]. A series of new practices have been implemented in the utilities to improve their efficiency, to prepare for new strict regulations, or to handle crises.

Although benchmarking seems ordinary, it can support water utilities to earn higher productivity. Benchmarking is a systematic process of searching for best practices, initiatives and effective operating procedures that lead to superior performance. Clearly, no individual or team can create all innovations. Likewise, no water utility or consulting company can come up with all good ideas. By investigating the best practices, operating tactics and management strategies of other water utilities, that water utility can speed up its own progress and improvement. Consequently, if these best practices from a number of water utilities with high performance can be documented, other water utilities can use the practices as models for their own.

The set of indicators called Aquagauge, developed by Michael Garvin, is the example of efforts to benchmark in water industry. Aquagauge provides a great deal of

easy-to-use data from 62 water utilities across the USA. This indicator sets include six different data areas i.e. financial data, management systems, infrastructure system, economic setting, water quality, water delivery, and general information. The utility rating data, acquired from credit rating institutions like S&P, Moody, or Fitch IBCA, in this data set can be used to create a shortlist of water utilities with acceptable overall performance.

1.2 Objectives

The purpose of this thesis is to investigate the Best Management Practices in the well-performed water utilities and their settings or limitation by examining examples of six water utilities. These case studies are then evaluated to determine whether they might serve as models for other utilities to follow.

2 Methodology

2.1 Sources of Information

The main sources of information in this research are annual reports, web sites, and publications of water utilities. Supplemental information of the utility settings is from an encyclopedia and web sites that provides perspectives from the other side of the story.

2.2 Outline

This thesis has three parts: case studies, discussion, and summary. Each case study investigated city background, water utility overview and specific practices such as water resource planning, watershed protection programs, water conservation program, capital improvement programs, infrastructure delivery systems, initiative concepts, and wholesale contracts. At the end of the case study, a summary of that case restates problems, practices to solve the problems, and factors contributing to success. In the discussion part, the relationship of water utilities settings and their practices is examined. Finally, the last section summarizes the findings and discusses the future study.

2.3 Approach to Case Studies

As shown in Table 2.1, the case studies of water utilities are selected by their utility debt ratings, geography, size or capacity of water utility, the type of ownership, and the average income of the state. Therefore, some candidates are from arid area of the southwest, while some have enough water resource to become water wholesalers. Many of them have been through situations like drought, financial crisis.

Table 2.1 List of Candidate Water Utilities and Documented Best Practices[13]

Utility Name	New York City Water & Sewer System (NYW)	Los Angeles Department of Water & Power (LADWP)	San Diego County Water Authority (SDCWA)	Seattle Public Utilities (SPU)	District of Columbia Water & Sewer Authority (DCWASA)	Portland Bureau of Water Works
Utility Rating	AA	AA	Aa-	AA	A1	Aa1
City	New York	Los Angeles	San Diego	Seattle	District of Columbia	Portland
Population Served	7,400,000	3,807,500	2,800,000	1,300,000	550,000	840,000
Average. income of the state ($/year)	38,479	42,262	42,262	46788	35,309	39,768
Average flow rate (MGD)	1,310	555	429	145	137	108
Ownership	Municipal, independent authority	Municipal, independent authority	Regional, independent authority	Municipal, department	Municipal, independent authority	Municipal, department
Wholesales	No	No	Yes	Yes	Yes	Yes
Water Conservation		Page 26	Page 30	Page 39		Page 53
Water Resource Planning		Page 24	Page 32			
Watershed Protection Program	Page 13					
Wholesale Contract				Page 38		Page 54
Initiative Concept				Page 41	Page 47	Page 55
CIP	Page 17		Page 34		Page 46	

These case studies are used to investigate city backgrounds, utilities backgrounds, and practices used. Through these cases studies, general detail of practices and stakeholders are documented from the perspective of water utility.

After setting up the framework of settings as shown in Table 2.1, the water utilities were studied to identify practices in the following areas:

- Water resource planning and management
- Water conservation program
- Watershed Protection Program
- Initiative Concept
- Wholesale Contract
- Capital Improvement Program

2.4 Best Management Practices

The definition of Best Management Practices in this research covers a policy, program, practice, or the use of devices, equipment that meets the following criteria:

(a) An established and generally accepted practice among water suppliers that results in more efficiency in water utility:

(b) A practice for which adequate data are available from existing other water utilities to indicate its benefits; and that the practice is not otherwise unreasonable for most water suppliers to carry out.[3]

3 Case Study of Best Management Practices

3.1 Case Study1: The New York City Municipal Water Finance Authority

3.1.1 City Overview

New York, the largest city in the United States, is located at the mouth of the Hudson River on the southernmost extension of New York State. The population of the City is 7,322,564 (1990) with approximately 1.2 million tourists visiting daily. The city is divided among five boroughs, each of which is a county of New York State: Manhattan (New York County), Brooklyn (Kings County), the Bronx (Bronx County), Queens (Queens County), and Staten Island (Richmond County)[9]. Average income of the State is $38,479 per year[13].

3.1.2 Utility Overview

New York City Water & Sewer System (NYW) provides water and wastewater services to New York City. The system has two separate and independent corporate bodies: the New York City Municipal Water Finance Authority and New York City Water Board. In addition, the New York City Department of Environmental Protection operates the City's water and sewer system.

NYW serves the population of nearly 7,400,000 with its water demand of 1.3 billion gallons per day and its estimated growth rate of 2.9 % from 1990 to 1999(US Consensus Bureau). As shown in Figure 3.1, the source of water supply is a network of 19 reservoirs in a 1969 square mile watershed located 125 miles north and west of New

York City. The Croton system provides about 10% of the daily consumption from 12 reservoirs and 3 controlled lakes in Putnam and Westchester Counties. The other 90% are from six reservoirs in the Catskill/Delaware system west of the Hudson River.

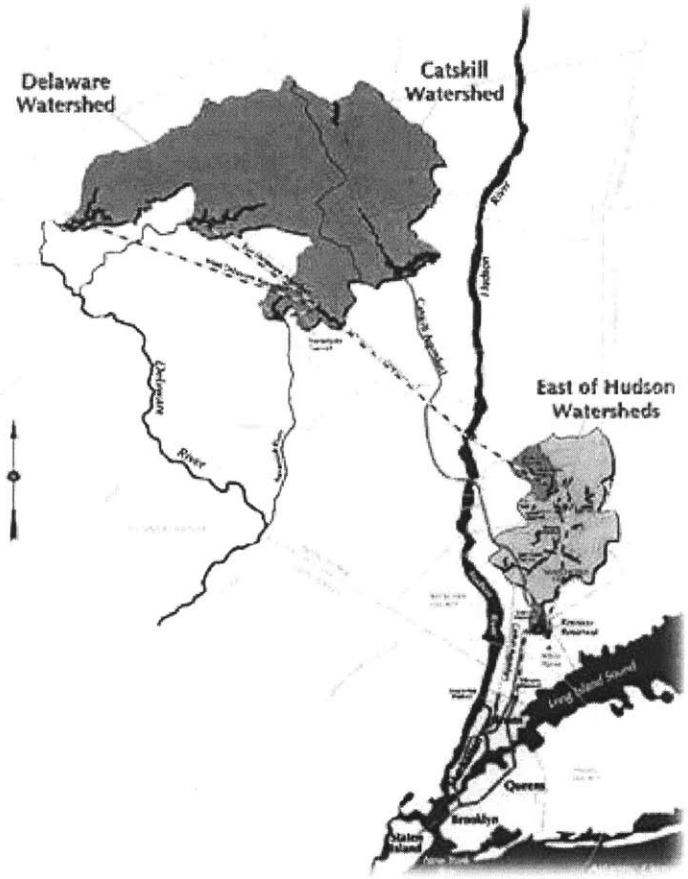

Figure 3.1 Map of three watersheds that supplying water to the New York City[1].

Because of the federal Surface Water Treatment Rule, the USEPA requires water utilities to filter its water, if their water sources are surface water. Consequently, the water supply facilities of New York City are under this regulation. However, since January 1993, the USEPA has waived the requirement of NYW to filter its water from its Catskill and Delaware systems on three occasions. This determination of USEPA

includes a number of conditions that the City is required to achieve in order to ensure that the City will continued to be relieved of requirement for filtration.

3.1.3 Approach

Tax revenue from New York City is one major source of the state income, which indirectly supports 79 municipalities—towns, villages, and communities in the Catskill, Delaware, and Croton watershed area. On the other hand, the watershed areas in these communities are main water sources of the City. The pristine condition of its water sources postpones NYW's immense investment in the filtration facilities due to the Surface Water Treatment Regulation of the USEPA. In addition, the Catskill, Delaware, and Croton watersheds are located in independent municipalities and economic planning authorities where New York City cannot intervene. A win-win agreement between the stakeholders in both sides is required for a mutual benefit in a watershed protection program. Besides, a ten-year capital improvement programs (CIP) in New York City projects approximately 9.1 billion to improve standard of the City infrastructure. More than half will be in water and wastewater facilities. This case study will describe NYC's practices of Watershed Protection Program and Capital Improvement Program.

Watershed Protection Program

In the early 1997, New York City and New York State signed a Memorandum of Agreement with the communities in Catskill, Delaware and Croton watershed, the EPA, and many environmental groups to support an enhanced watershed protection program for the City drinking water supply[1].

The Agreement illustrates the scope and execution process for three major parts of this revised watershed protection program:

- Land Acquisition and Stewardship Programs
- Watershed Protection and Partnership Programs
- Watershed Regulations

Land Acquisition and Stewardship Programs

The objective of the Land Acquisition Program is to acquire the land near watershed area, establish a rehabilitation program, and limit activities that might affect the quality of watershed. The approaches of outright purchase and land easement have been adopted through this program. Under the Agreement, the State Department of Environmental Conservation issued a 10-year land acquisition permit to the City. With the Agreement and the permit, the City has authority, through outright purchase or through conservation easement, to acquire interest in undeveloped land near reservoirs, wetlands and watercourses, or land having certain natural features that are water quality sensitive. In this program, the City commits to spending $250 million on land acquisition in the watershed of Catskill/Delaware system and $10 million in the watershed of Croton system. However, the Agreement prepares municipalities in the area a local consultation process to ensure that the City regards the comment and concern of watershed towns and villages when it proposes to acquire their property.

The Agreement defines and prioritizes the projected areas into four groups. Each

group of areas is set its milestone acreage for this program. The City must contact the owners of over 350000 projected acres of eligible land in the Catskill/Delaware watersheds, although it has no requirement to buy a specific amount of acreage. However, the villages can exclude certain parcel of land in the villages from land outright purchase. Some details may vary from area to area. The Towns west of the Hudson River can exclude commercial and industrial area up to 50 acres in some priority lands. Still, in all cases the City has its authority in land acquisition through conservation easements.

Watershed Protection and Partnership Program

The Watershed Protection and Partnership Programs section of the Agreement promotes and establishes widely cooperation and planning in the watershed area. On hoping that the effort builds the strong relationship between the City and its upstate neighbors happens, the establishment of many watershed protection initiatives in local area is funded by the City. Similarly, the Agreement establishes a Watershed Protection and Partnership Council, which serve as a regional forum for the discussion and review of water quality concerns and other related watershed issues[10].

Through the Agreement, a Catskill Watershed Corporation is created. It is nonprofit corporation with two main goals: to protect the water resources of the New York City Watershed west of the Hudson River, while preserving, and strengthening communities located in the region[7]. This locally based corporation administers major portion of the approximately $240 million due to water quality and economic development programs west of Hudson that the City has been committed. The City also

has to spend nearly $70 million on the similar program on the east of Hudson. The Catskill Watershed Corporation establishes and implements several program:

- Catskill Fund for the Future (CCF): Loans and grants to businesses and organizations—$59.7 million.
- Economic Development Study: To guild and suggest the uses of CCF--$500,000
- Stormwater Controls for New Construction: Design, plan for the construction of new stromwater and soil erosion control--$31.7 million
- Stormwater Retrofit Program: Improving existing soil erosion and water runoff problems--$7.625 million
- Septic System Rehabilitation and Replacement: Residential septic repair—$13.6 million
- Alternate Design Septic Program: Subsidize the appearing costs due to watershed regulations of residential and commercial septic system--$3 million
- Sand and Salt Storage Program: Construction of storage for road de-icing chemicals for municipalities--$10.25 million.
- Public Education: $ 1 million grant for schools and organizations, $1 million funding for regional watershed museum.
- Tax consulting: Assist the municipalities on the west side of Hudson river to review and administer New York City property assessments and taxes--$ 3 million

New Watershed Regulations

The Watershed Regulations in the Agreement, substituting the last outdated standards,

will enhance the protection of the City's water supply quality. The regulations will approve the responsible development and improvement in existing population centers. Additional functions of this regulation are to establish standards for design, construction and operation of wastewater treatment plants; set design standards and setback requirement for septic systems; and require the implementation of stormwater control measures for variety of commercial, residential, governmental, and industrial projects. This regulation prepares the City expedited procedures in case of emergency and rights of appeal, with strict period for review and decision making, to review and approve certain activities having a potentially unfavorable impact on water quality.

The Final Draft Agreement was issued officially on September 10, 1997 to publicize to the communities for a three-month period. Public information sessions were held through out the watershed to present and clarify the Agreement to the public. During the period, all municipalities in the watershed all decided if their elected officials should sign the Agreement. At the same period, the new Watershed Regulations underwent public review as part of the City Administrative Procedures Act requirements, and DEC solicited comment on the land acquisition water supply permit.

Capital Improvement Program for the Water Facilities of NYW

The Capital Improvement Program (CIP) of the New York City, 2000-2009 program, contributes projected 9.1 billion to rebuild and improve the City Water and Sewer System's infrastructure according to the review of present condition and future needs of the plant and the equipment in the City's water utility.

The CIP combines the needs of legal mandates, the present preventive program for the facilities, expansion of the existing service area, the programs to enhance and optimize the operation of the Water and Sewer System. The goals of Capital Improvement Programs in the City's water supply facilities are to persevere the quality of the water in the City's watershed and treat the supply where necessary and to maintain and rehabilitate the transmission and distribution capacity.

The total CIP is consisted of five project types in its portfolio management plan. These projects lie on both water supply and wastewater facilities. Each part of the program has its plan and its projected budget as shown below.

Water Supply and Transmission:	$940 million
Water Distribution:	$2240 million
Water Pollution Control:	$4270 million
Sewer:	$1400 million
Equipment:	$240 million

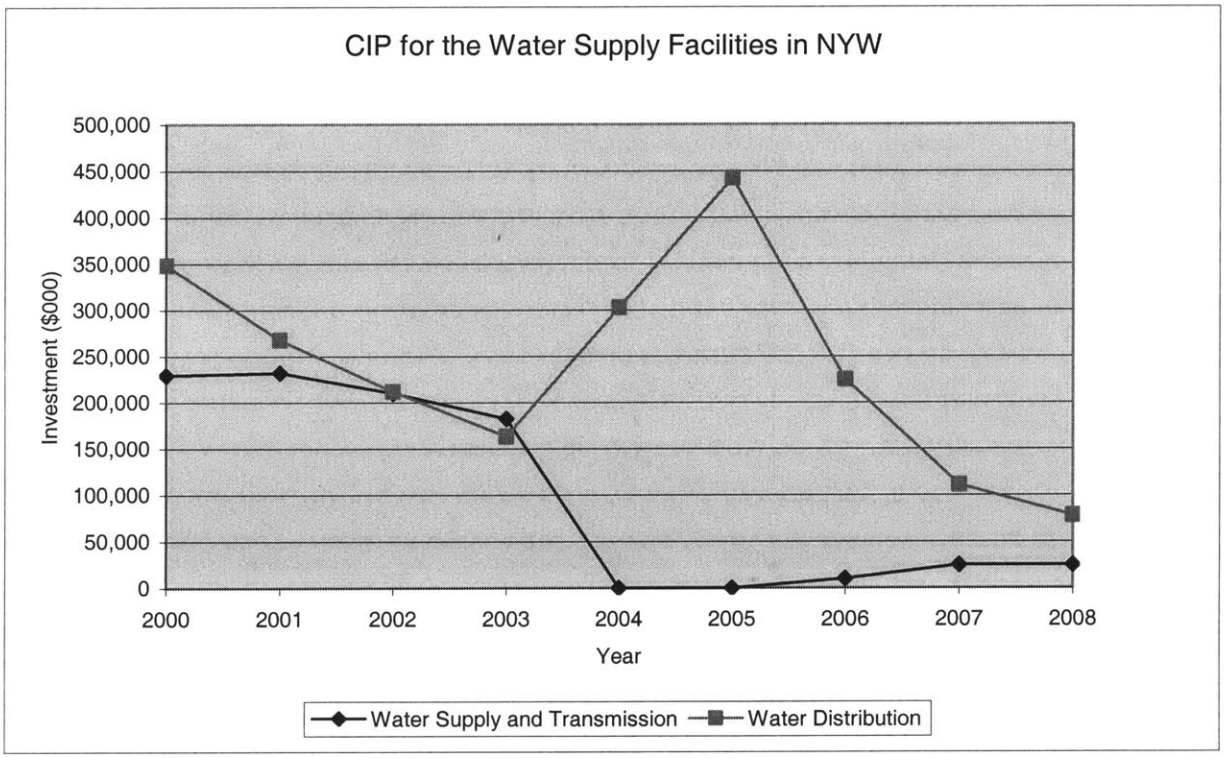

Figure 3.2 Capital Improvement Program for the Water Supply Facility in the New York City[5]

This research will document only two parts of related CIP programs, which are the program for Water Supply and Transmission Program and Water Distribution Program.

CIP for Water Supply and Transmission

Since 1917 and 1936, the Catskill and Delaware systems have supplied 90% of water consumption of the New York City, while the Croton watershed supplied the balance. The 125-miles aqueduct conveys water from the northern of the State and the west of Hudson River to the southern part and the east of the Hudson River. The last part of

Aqueduct locates in the south of Croton watershed is branched into tunnel 1 & tunnel 2. The water main tunnels go underground to a Staten Island water facility that distributes water to the customers. Because of no redundancy in water transmission system, tunnels No.1 and 2 have never been inspected and repaired since their first operation in 1917 and 1936.

Table 3.1 Capital Improvement Program for the Water Supply & Transmission[5]

Systems in the Water Supply & Transmission	Ten-year investment (in million dollars).
City Tunnel No. 3, stage1	327.69
City Tunnel No. 3, stage 2	526.31
Reconstruction of Tunnel No. 1	85

The CIP for Water Supply & Transmission includes the construction project of the tunnel no. 3, which will expand transmission capacity from the watershed and enable the renovation of tunnels no.1 & 2. The construction project of tunnel no.3 is the largest capital improvement project in the City's History. As shown in the Table 3.1, the construction project of tunnel no. 3 in stage 1 & 2 worth approximately 857 million. With the capacity equals to two existing tunnels capacity, it will be the full redundancy system of the tunnels no. 1 and 2. The Department of Environmental Protection will inspect and maintenance the tunnel no.1 from 2006-2009.

CIP for Water Distribution

The New York City's drinking water is rated as one of the best water in the United States. The CIP for water distribution system, to maintain the City's quality of drinking water, has its projected 2.2 billion budget for the period 2000-2009. This comprehensive plan is consisted several parts as follows:

Table 3.2 Capital Improvement Program for the Water Distribution[5]

Systems in the Water Distribution	Ten-year investment (in million dollars)
Trunk and Distribution Main Replacement program	592.43
Trunk and Distribution Main Extension	209.42
Croton Filtration Project	921
Dam Safety Program	136.61
Water Quality Preservation	369.11
Augmentation of Water Supply Systems	1.37
Corrosion Protection Program	2.30
Miscellaneous Improvement Upstate	1
Mapping & Telemetry	2.80

3.1.4 Summary of Case Study 1

The USEPA has enforced Surface Water Treatment Rule (SWTR). Therefore, every water utility where surface water is a water source has to filter water before distributing; New York City (NYC) is under this condition. However, due to the high construction cost of filtration facility, NYC decided to find alternatives that comply with SWTR, while avoiding building the new filtration facility.

Consequently, NYW implemented two practices with lower investment: watershed protection program and capital improvement program (CIP). Although these two practices have been used in NYC before, the contents and budgets were adjusted to serve a new objective of filtration avoidance. With the strong support of New York State, NYC and 79 upstate communities around watersheds has signed a comprehensive Memorandum of Agreement Regarding Watershed Protection Program. Through this Agreement, NYC has an authority to preserve outside-city watershed areas in Catskill, Delaware, and Croton system. In addition, as part of new CIP, NYW has built a costly water tunnel no. 3 project to expand capacity and earn redundancy of water trunk system. After completion of the tunnel no. 3, this redundancy will allow NYW to perform maintenance on existing tunnels no. 1 and no. 2 for the first time since they have been operated since 1917 and 1936 respectively.

The factor contributing to success in this case study is the support from New York State. SWTR enforces NYC to choose either to build new water filtration facility or to develop an enhanced watershed protection program. However, strong support from New

York State assisted the upstate communities and NYC to settle an agreement faster. A factor of a strong support from the State might not be easily repeatable elsewhere.

3.2 Case Study 2: Los Angeles Department of Water and Power

3.2.1 City Overview

Los Angeles, located on the Pacific coast of southern California, is the seat of Los Angeles County. With 3,553,638 (1996 est. pop.) inhabitants, Los Angeles is the second most populous city in the United States[9]. An average income of State is $42,262.[13]

3.2.2 Water Utility Overview

Los Angeles Department of Water and Power (LADWP) has established as an independent authority of the City of Los Angeles since 1925. It provides water and power services; the Department's Water Services is responsible for the procurement, quality, and distribution of water for sale in the City. Due to its geography and climate, LADWP imported almost all water supplies to feed the City and its economy growth.

3.2.3 Approach

The water supplies of LADWP are from three major sources: Los Angeles Aqueducts (LAA), local groundwater, and Metropolitan Water District for Southern California (MWD). Water shortage in the City has been mitigated by water imported from LAA and MWD. However, LAA, which delivers half of water supply to the City, acquires water from snowpack in Sierra Nevada, which fluctuation occurs from year to year. During the drought during 1987-1992, the drought decreased water supply capacity from LADWP's

main source LAA. In addition, MWD ordered all water agencies to cut back water usage significantly. Inevitably, this drought scenario in Los Angeles threatened business sectors and the competitiveness of the City. The authority, citizens, and business have realized that water is a simply fuel of economy. A strategic water resource planning and procedure is required to sustain the growth of the City.

Water Resource Planning and Management

Currently water consumption in Los Angeles is approximately 640000 acre-foot per year. The growth rate of water use is still increasing, but the rate of increase is 1.3%, which is lower than 2.1% of the last decade. However, the projected water use in next 20 years will be 800000 AF per year, its available water sources in the next 20 years will be about the same number. The water agencies in California including Los Angeles will continue to work on matching these two numbers to guarantee the viability of their Cities.

The Los Angeles Aqueducts, local groundwater, and the Metropolitan Water District of Southern California are primary sources of water to the City. As shown in Figure 3.3, LAA supplies more than half of water consumption. Because this source provides the most cost benefit effectiveness, LADWP tries to maximize its ratio. However, this source is from snowpack, its availability is fluctuated from year to year. In addition, this largest water source of the City is now limited its delivery to 321,000 AF due to an environmental concern in Owen Lake.

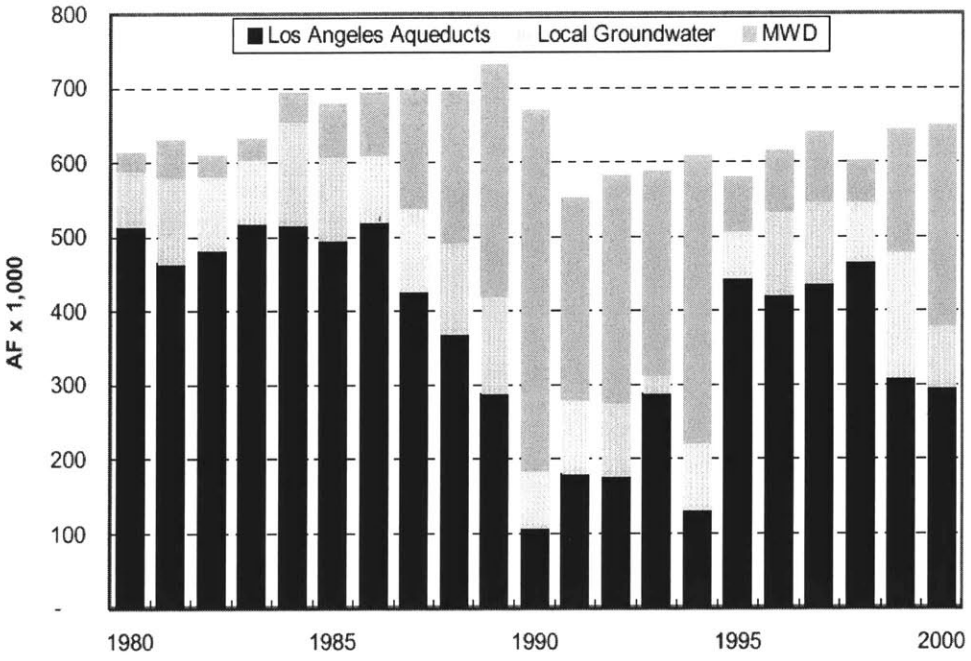

Figure 3.3 Historical Water Supplies in LADWP[4]

Local ground water provides high quality and steady supply of water. Over the last decade, this groundwater has been 15 percent of water supply or 92,400 AF. More than 90 % of this groundwater is from San Femando.

Metropolitan Water District, established to serve regional growth in Southern California, is now the largest water wholesaler to 27 water agencies. LADWP tries to minimize the uses this water source. However, MWD is always a backup water source, whenever the City faces drought. As seen in Figure 3.3, the ratio of water from MWD increased rapidly during the drought period of 1987-1992.

LADWP researches for alternative water sources such as recycling water, desalinated seawater, water marketing, stormwater runoff. In this group, recycling water is the most tentative source. LADWP will displace 74,000 AF per year in 2020 of the non-potable water use. As part of recycling water project, an East Valley Water Recycling Project will provide 35000 AF per year in 2005.

Water Conservation Program

While struggling to find more water sources, LADWP implemented all 16 best management practices in water conservation program in the MOU signed by MWD and its 27 members. Currently, daily water demand per capita in the City is approximately 135 gallons, comparing to the national average of approximately 180 gallons. Since the foundation of the California Urban Water Conservation Council (CUWCC), LADWP has played role in governance and policy making in this council. According to the Memorandum of Understanding Regarding Urban Water Conservation in California (MOU), LADWP has adopted the Best Management Practices suggested in the MOU as part of its conservation plan. As one of the signatories to the MOU, LADWP is obligated to annually submit a Best Management Practices Retail Water Agency Report to the CUWCC. The list of conservation measures has been continuously introduced to the customers, as shown in Table 3.3. Because the period of the implementation was just after the drought cycle in 1987-1992, the memories have led the program to a significant achievement in water usage reduction.

Table 3.3 Potential Measures Previously Identified and Implemented.[4]

Conservation Measures	Implementation Date
Replace Toilets with Ultra-Low-Flush	1990
Public Agency Retrofits (through TAP and ULFT programs)	1990
Large Industrial Incentive Program (through TAP)	1991
Industrial Cooling Water Study	1992
Large Industrial Incentive Program	1992
Ascending Block Rate Structure	1993
High-Efficiency Washing Machine Rebate Program	1998
Homeowner Association Irrigation Study	1999
Landscape Education (in English and in Spanish through Protector del Agua Program)	1999
ULFT Installation On Resale Ordinance	1999
Evapotranspiration-Based Irrigation Controller Program – pilot	2000
Toilet Flapper Program – pilot	2000

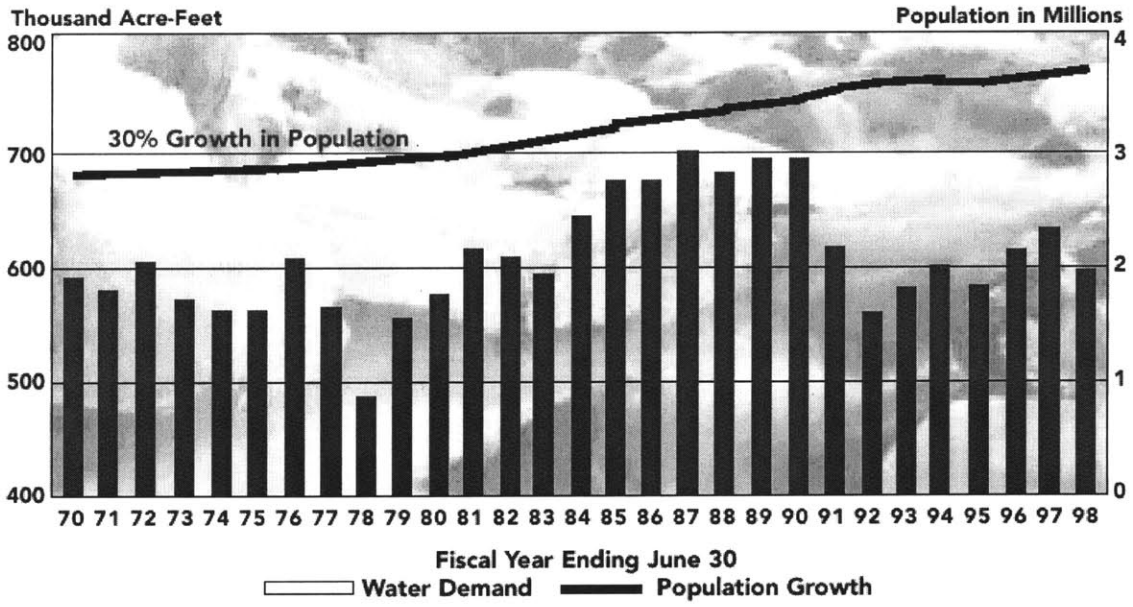

Figure 3.4 Los Angeles Water Demand and Population (in acre-feet) [15]

The achievement of water conservation program is as shown in figure 3.4, water consumption in Los Angeles in 1998 was equal to the consumption in 1970, although its population has increased by 30 %.

3.2.4 Summary of Case Studies 2

Los Angeles has had continuous growth of economy and population since early 1900s. However, California is an arid state, drought cycle affected availability of water source from time to time. Despite this limited water resource, LADWP attempts to provide sufficient water supply to maintain the rapid economic growth of the City.

LADWP has used water resource management and water conservation program to handle water scarcity issue since 1913. Nowadays, LADWP has three water sources that have different prices and condition of usage. LADWP manages ratios of its water sources to earn a combination of the lowest price. Water conservation program has been a norm of the City. Thus, alternative water source like recycling water and several water conservation programs have been introduced to minimize the growth of water demand.

The factor contributing to success in this case is the vision of the City that has recognized an importance of water resource management for a long time. Therefore, it has allocated water from alternative water sources since early 1900s. The setting of water shortage in California encourages citizens and politicians to support water conservation program to decelerate growth of water demand to match available water resource and capacity of water supply infrastructure.

3.3 Case Study 3: San Diego County Water Authority

3.3.1 City Overview

San Diego is a semi-arid County and the second largest city in California. The city population is about 1,171,121(1996est), and metropolitan San Diego, 2,498,016(1990)[9]. The economy of the greater San Diego area is based on various industries such as aerospace equipment, computers and electronic equipment, clothing, processed food, etc. About one third of its manufactured products are exported. An average income of the City is $42,262 per year[13].

3.3.2 Water Utility Overview

San Diego region relies strongly on imported water. In fact, San Diego can supply water to a population of around 50,000 with its own water resource. With this necessity, the City of San Diego has an active and recognized water conservation programs. Like other cities in the US, the City's infrastructure challenges were complicated by several other needs and day to day crises. However, the City of San Diego is a good example that develops a strategic plan for capital improvement program.

3.3.3 Approach

The City of San Diego has its water conservation programs and capital improvement programs that can be suitable for water utilities that face problems of low maintenance infrastructure and water shortage. This research documents these two practices of the utility.

Water Conservation Program:

Because of the following Water Conservation Program, the City of San Diego received an award for its active programs. The below water conservation programs are based on a solution that customers and the utility earn benefit at the same time:

- Landscape Watering Calculator
- Ultra Low-Flush Toilet Rebate Program
- Residential Water Survey Program/Business Water Survey Program
- Selling or Buying a property in San Diego: Water Conservation Ordinance.

Landscape Watering Calculator

This program provides a handy tool that supports its customers to estimate the appropriate amount of water to use for their landscape or garden. As shown in Figure 3.5, the Landscape Watering Calculator can give the customers a weekly schedule for the maximum amount of water required for each month of the year. To be more specific for a condition of San Diego, the calculator uses average number of weather, plants, and soil condition in the city. Above is the appearance of the Landscape Watering Calculator used in San Diego.

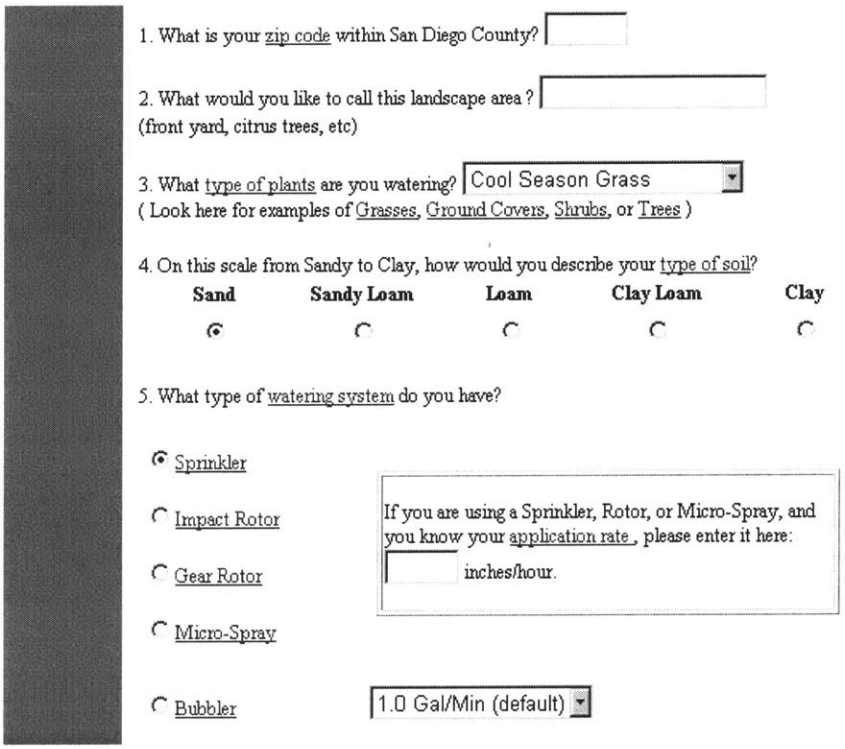

Figure 3.5 Landscape Watering Calculator in the San Diego Water Utility[8]

Ultra Low-Flush Toilet Rebate Program

The Ultra Low-Flush Toilet (ULFT) Rebate program allows the San Diego residents to lessen their water consumption by arranging a financial incentive to replace high-volume flush toilets. By this program, the participated residential, commercial, industrial customer of the City of San Diego can receive cash rebates up to $75 per ULFT that replace the 3.5 gallon per flush or greater toilets.

Residential water survey report/ Business water survey report

Both of these citywide programs provide assistance and recommendations to its customers by analyzing water use patterns including suggesting water conservation plan.

For the residential water survey report, the program objective is to educate and develop customer awareness of water conservation practice. It is offered free of charge to single family and multifamily water customers. Through this program, the program representatives will visit the customer property to identify leaks and water conservation alternatives indoor and outdoor area of the house. However, the program emphasizes the present of the customer at the time of the survey. Participated family can receive water-saving equipment and information.

On the contrary, the objective of the Business water survey report is to offer cost-effective advice and schemes in businesses, production plants, hospitals and other nonresidential facilities to improve the customer's water use patter and reduce the consumption without affecting processes or production capacity. The program provides financial incentives for implementing certain retrofit recommendations.

Selling and buying property in San Diego

San Diego Municipal Code Ch.14, Art 7, Div 4 requires that all buildings, prior to a change in ownership, be certified as having water conserving plumbing fixtures in place.

Improvement of Water System Reliability

On March 1991, MWD ordered San Diego County to increase its water cut back from 31% to 50%, after the drought in California had occurred for 5 years. Unlike LADWP, San Diego County did not have other sources of imported water to subsidize the drop of MWD's water. The City has survived its major economic collapse, because miraculous

heavy rainfall saved the county from the 50 percent cutback. However, the threat to economy has changed policies of the County towards its sole imported water supplier MWD to be a more reliable policy. Since then, several efforts as shown in figure 3.6 have take place to create higher reliability in water systems:

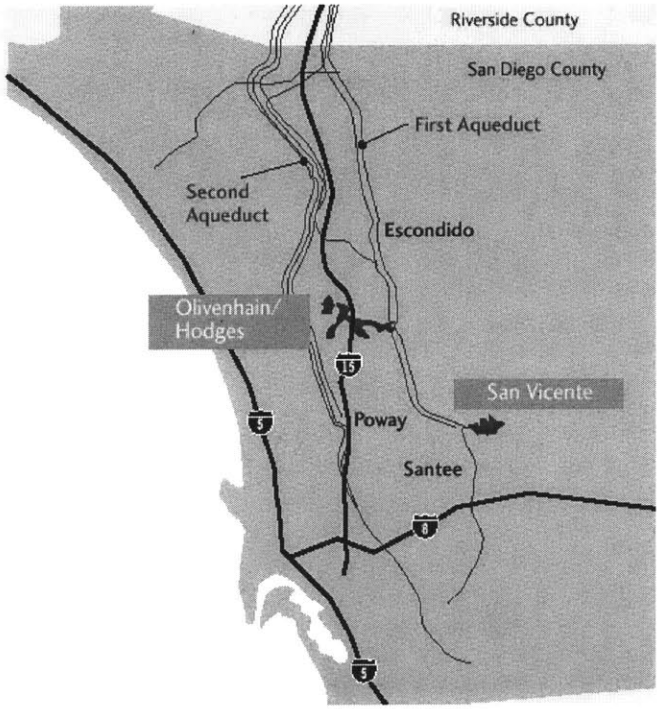

Figure 3.6 Map of Water Systems in SDCWA[16]

- Project 1: Valley Center Pump Station will be a facility to pump treated water from the Second Aqueduct into the First Aqueduct or vice versa. This pump station can create flexibility and enhance reliability of this water system. The construction of this project is expected to be complete in Spring 2001.
- Project 2: Olivenhain Dam is constructed to provide 24000 AF reservoir and increase the storage of San Vicente Dam by 52,100 AF. The completion will be by 2010.

- Project 3: Twin Oaks Valley Diversion Structure is a 22-million gallon water storage, which will store water that backs up in the pipeline when member agencies refuse water that already send out.
- Project 4: Aqueduct Protection program is a risk management procedure that is mainly an inspection, preventive maintenance and repair program.

In addition, SDCWA adds other water sources to enhance the reliability of its water sources. The portfolio of water source in San Diego County is as follows.

- Source 1: Metropolitan Water District of Southern California
- Source 2: Water exchange program between MWD and the San Diego County's Imperial Irrigation Department.
- Source 3: Helix Water District
- Source 4: Sacramento-San Joaquin Bay-Delta estuary
- Source 5: Local water sources

Capital Improvement Plan

Like other water utilities in the US, the San Diego water utility has found the aging water infrastructure problem. Many specific problems could be grouped into the four categories:

- Inadequate resources had been available to the Department to perform needed work.
- Main water distribution system components needed to be replaced.
- Impact of economic growth
- Policy makers did not recognize the rate increase to maintain future system stability.

The Water Department addressed the issues by systematically developing a comprehensive strategic plan to summarize the City's needs for water. This plan points the needs in local water development programs and water treatment and distribution systems to maintain the reliability of clean, safe water for its customers. After it obtained a comprehensive Capital Improvement Plan, the Department failed in its persistent attempt to receive funding from the City Council to support the plan. The Department changed its strategy by raising the awareness in the community about the aging infrastructure and increase public support for the deficient funding. The City educated the public on the condition of its water treatment and delivery facilities in order to obtain the public support in the multi million capital investment plan, which includes the water rate increases.

The City invited more than 30 community members to participate in the so called Strategic Plan for Water Supply Public Advisory Group (PAG). PAG was created to synchronize the diverse interests and benefits of various communities into this planning document. The PAG's responsibility contain estimating the water need of the City of San Diego through the year 2015 including groundwater, desalination, recycled water for both potable and non potable uses. Besides, the PAG assesses the current condition of the City's water treatment and delivery facilities. The PAG also helped the City in developing an appropriate Capital Improvements Program. In August 1997, the City council approved a water revenue plan including an initial rate increase to support the capital improvement program.

3.3.4 Summary of Case Study 3

Comparing to Los Angeles, San Diego faces a more serious degree of water scarcity. The drought crisis in 1987-1992 led to economic crisis in San Diego. Water supply is simply a fuel of its economy. In addition, the water infrastructure of San Diego was aging and had never been sufficiently maintained. This aging water system creates problems of water quality deterioration and water loss.

After 1991, SCDWA has used rigorous water resource planning, water conservation program, and CIP to handle its near-crisis situation. The City implements several projects to earn a reliability of its water systems. An agreement of water exchange among Imperial Irrigation Department, MWD, and SCDWA represents a creative way to allocate water resource to the City. The City promotes the awareness of aging water infrastructures, which eventually earns supports from citizens to fund CIP through increasing water rate.

The factor contributing to success in this case is the strategy of the City to promote the awareness of aging water infrastructures. In addition, the drought crisis led to economy crisis in 1992. This scenario promoted citywide support of water conservation program and the projects providing reliability of the water system. However, the City would not have faced this crisis, if only it had prepared itself for the predicable drought cycle during 1987-1992.

3.4 Case Study 4: Seattle Public Utilities

3.4.1 City Overview

Seattle is the largest metropolis in the northwestern United States and is located in Washington. Seattle has a population of 524,704 (1996) in the area of the city and 1,972,961 (1990) in the greater metropolitan area.[9] The average income of the state is $ 46,788 per year.[13]

3.4.2 Water Utility Overview

Seattle Public Utilities (SPU) was formed in 1997 to consolidate functions of the water department and engineering departments i.e. solid waste utility, and drainage and wastewater utilities. The responsibility of SPU includes all water, sewage, flood control, and solid waste works in its service area. SPU serves a population of approximately 1,300,000. The water sources of SPU are from Cedar River and South Folk Tolt River. The new Tolt water treatment plant project schedules to filter water from South Folk Tolt River by the end of November 2001, while the Cedar water treatment plant project is in the process of procurement after the success in the Tolt water treatment plant project.

3.4.3 Approach

SPU has many good practices that should be investigate such as the approaches of handling wholesales customer contracts, its water shortage contingency plan, and its innovative infrastructure delivery system in the Tolt water treatment plant project. This research shows the practice of Wholesales Water Customer handling, Water Shortage Contingency Plan, and Water Treatment Plant Delivery System.

Wholesale Water Purveyors

Current direct wholesale customers include municipalities and water utilities that have contracts with SPU to purchase water from Seattle. Twenty-seven water districts and cities (purveyors) to the east and south of Seattle purchase water directly from SPU to sell to their customers. All together, these purveyor contracts buy about 40 % of Seattle's available water at wholesale price. Consequently, these contracts create high ratio of revenue to SPU. However, several utilities try to locate and develop additional supplies from local groundwater sources. The East and South King County CWSP can choose either the Seattle or Tacoma regional water systems to meet their needs. Thus, long term contracts between the wholesale purveyors and SPU will ensure that the predictable utility's revenue stream.

In 1928, 28 cities, water districts and associations signed 30-year contracts to buy some or all of their water from Seattle on a wholesales basis. Below is the Term of Contracts from the original contract—Version B between SPU and its wholesale customers.

I.A. Term of Contract

1. Subject to the other provisions contained herein, the original term of this Contract shall commence and this Contract shall become effective on the date of the City's execution hereof. This term shall continue and this Contract shall remain effective until January 1, 2012.

2. Subsequently, the contract term shall be extended for additional fifteen 15) year

increments, provided both parties express their intent to do so in writing at least fifteen (15) years prior to the end of the contract term or extension thereof. [12]

Because the revenue of wholesale customers is about 26%, the term of contract and condition of contract extension are crucial point to sustain the viability of SPU business. Clearly addressed in the above topic 2, the extension of contract needs to be negotiated 15 years prior to the end of the contract term on January 1, 2012. Consequently, on January 1, 1997 SPU knew if any consumer would not extend the contract after the end of normal contract term. With 15 years prior to the end of contract, it has enough time to adapt its business plan and lessen the risk of revenue stream fluctuation.

Water Shortage Contingency Plan (WSCP)

The Seattle water system has experienced two different types of droughts in recent history. It experienced two cases of droughts in 1987 and 1992. In 1987, the summer weather was unusually warm and dry, the higher than normal evaporated water speeded up the drawdown of the storage reservoirs. In early fall, an emergency pumping station was installed at the Chester Morse Lake reservoir to pump "dead storage", which led the reservoir level to fall below the natural outlet level of the lake. Not until February 1988 that precipitation returned to normal and began filling up the reservoir.

In 1992, another type of drought occurred. That winter was unusually warm, so snowpack and water flows into the storage reservoir were at record low levels. It was not

until the September of the following year that the water level in the reservoir returned to its normal level. In addition, during 1997-98, one most important El Nino weather events occurred. It makes SPU concerned the potential effect of unusual warm winter phenomena on snowpack and reservoir level again. With that potential drought, SPU adopt the Water Shortage Contingency Plan (WSCP) for both retail and wholesale customers.

The following is main points of this program. The WSCP offers instruction to SPU during the water scarcity, especially those of unusually dry weather that occurs in some period. The WSCP is designed from the records of a peak season drought. However, the revised WSCP includes water shortages because of other basis. The WSCP plan is formulated as per four stages:

- Advisory stage: The public is notified as soon as indicated data can predict that a potential shortage may occur.
- Voluntary stage: If the supply condition worsen, the plan shifts to the 'Voluntary' stage, which bases on voluntary cooperation and support of both residential and commercial customers to receive the consumption goals.
- Mandatory stage: If the Voluntary Stage does not result in the expected reduction, the Mandatory stage prevents or restricts certain activities. An enforcement plan such as fines for repeated violation includes in the stage.
- Emergency curtailment: In case of the most severe need for demand reduction, this could be the last stage of an incident, such as long term severe drought or an

emergency like a facility failure.

- Emergency curtailment relies on a combination of mandatory curtailment measures and rate surcharges to acquire efficient demand reduction.

Water Treatment Plant Delivery System

In 1995, the City of Seattle was pursuing a design-build-operate (DBO) approach to acquire its first filtration plant the Tolt Water Treatment Plant Project. Mostly the procurement approach of infrastructure project is a traditional design bid build approach. Rather, the City of Seattle decided to use the DBO approach, which saved a budget of the City up to 70 million dollars from 156 million dollars of the project benchmark cost.

Design Build Operate (DBO) is defined as a delivery method in which the Client—for example, the city, the states—procures design, construction, maintenance, and operation of the project from a single bidder or proposer. The Client provides initial planning and functional design. The DBO procurement method is defined to require that the Client directly provide some portions of cash flows required by the bidder to finance all of the tasks assigned by the Client[19]. DBO has a potential increase in efficiency in the construction and operating processes, because DBO encourages collaboration among the designers, contractors, and operators. This circumstance leads the project to reduce the project delivery time and budget—on the order of 10-15%.[20]

To enhance an effectiveness of the DBO approach in the Tolt project, Seattle Public Utilities (SPU) hired a group of consultants from R.W. Beck, Inc., Malcolm

Pirnie, Moore, Culp and Raftelis to examine the costs and the methods to design, construct, and operate the plant. These consultants investigate the project based on the Design Bid Build scenario. They developed benchmarks of design, construction, operation, and cost estimation. In the investigation, the team breaks down the unit costs of labors, power, supplies, chemicals, maintenance, and equipment replacement. The cost and revenue stream was converted to a Net Present Value (NPV) by using the rate that the City expected to be charged for the City's tax-exempt bonds. All proposers were asked to do the same for their proposals at the same discount rate. SPU required that all proposals were compared with the same method.

On the other hand, the benchmark helps the proposers understand the basic need of the City. DBO allows wide range different types of technology, equipment, cost and revenue structure. Many times, it is difficult for the Client to compare and award the proposals between diverse concept and presenting method. The benchmark study allows the Client to provide more details of project requirements in the Request for Proposal. This eventually benefits the ease in assessing proposals in a bidding process.

After its first achievement in saving 70 million dollars in the Tolt project, the City started its second filtration plant at the end of year 2000. The procurement of a second project, the Cedar water treatment plant, is also a design-build-operate approach.

3.4.4 Summary of Case Study 4

Seattle Public Utility provides 60% of water production to its retail customers in the City

and the balance to 28 wholesale customers. SPU requires long term contracts to sustain its revenue stream. In addition, the Tolt River and the Cedar River, major water sources of the City, occasionally have high turbidity. Therefore, at that time SPU has to close water inflow gates to sustain water quality in its water reservoirs. Besides, a couple of potential drought occurred in the past ten years; SPU prepares a water contingency plan.

As mentioned, the ratio of wholesales customers is high for SPU. Therefore, SPU sets a 30-year contract. In addition, SPU asks these customers to confirm contract renewals 15 years prior to the completion date of contract. To minimize the fluctuation of water turbidity in the river, SPU decided to build the Tolt Water Treatment project. SPU used a Design Build Operate approach as an infrastructure delivery system for the project and save approximately 70 million or 40% of its benchmark price.

Factors contributing in success of this case study are its good geographic settings and an efficient management team that provides a long-term strategic business plan for the utility. The practices in each department have a clear goal and strategy to support the overall achievement of utility. SPU is a model for other utilities.

3.5 Case Study 5: District of Columbia Water and Sewer Authority

3.5.1 City Overview

Washington lies in the southeastern United States, between Maryland and Virginia. It is the only American city or town is not part of any state. Washington covers the entire area

of the District of Columbia, a section of land that is under the jurisdiction of the federal government.[9] An average income of the City is $35,309 per year.[13]

3.5.2 Water Utility Overview

The District of Columbia Water and Sewer Authorities (WASA) has established as an independent regional entity since 1996. Funding for operation and facilities improvement is from user fees, federal grant and the sale of revenue bond. WASA serves diverse customers in the multi-jurisdictions such as the federal government, the District government, the surrounding jurisdictions in Maryland and Virginia and commercial and residential customers within the district.[6] It provides services to more than 500,000 user accounts. In addition, it collects and treats wastewater for 1.6 million customers in Montgomery and Prince George's Counties in Maryland and Fairfax and Loudoun Counties in the region. The Blue Plains Wastewater Treatment Plant, which serves those customers, is the largest advanced wastewater treatment plant in the world.

Approximately 38 percent of WASA operating revenue come from federal, municipal or county governments; 40 percent of the revenue are from commercial entities which their business run by the regional economy; and only 17 percent of its revenue are from residential customers in the District. This combination of customer types provides stability in its earnings.

3.5.3 Approach

During 1990-1996, the Water Service entity served in this area was one department of a government. Its performance brought concerns of its financial viability. As shown in Figure 3.7, the net income during 1990-1996 was low and unstable. WASA was established with the objectives to be an independent regional entity to effectively serve the customers with high performance. Since its first year, the Board has been successful in implementing several initiatives and approaches.

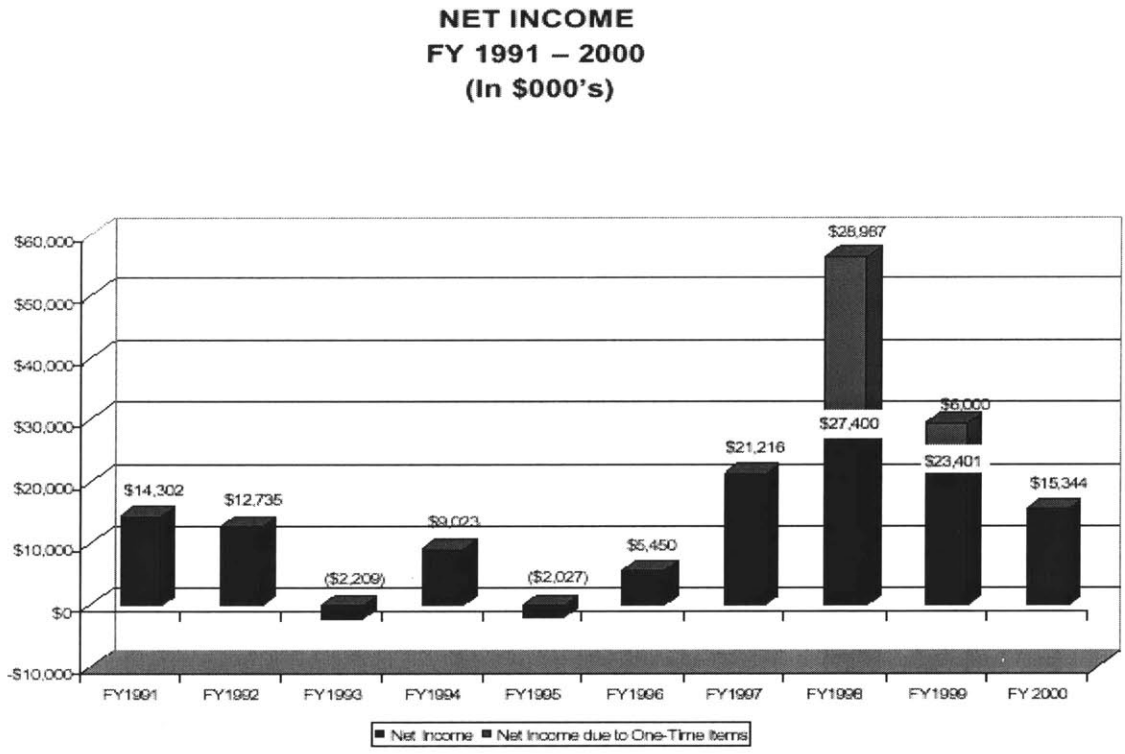

Figure 3.7 WASA's Net Income during 1991-2000 in WASA Case Study[6]

In general, these improvements can be categorized into financial practices, engineering or operating practices, and human resource management. WASA utilizes several programs to maintain and enhance water supply productivity and quality. The revised ten-year Capital Improvement Program has ensured for the new regulatory and

facility renovation needs. With a continued self-assessment practice, WASA claimed to be able to acquire same efficiency level as that a private sector can provide. This research shows the practice of Financial Practice, Operation Practice, and Human Resource Management.

Financial Practice:

Since its early year, WASA has adopted long-term financial plans and updates. These plans are a reason of the Authority's achievement of its financial, regulatory, and operational goals. Those plans include:

- A revised 10-year capital improvement program, which worth 1.6 billion, prepares WASA to meet the future regulatory and facility renewal needs. On hoping that, this capital improvement program will continue internal improvement and reengineering processes in each of activities. In addition, it expects to constantly decrease operating and maintenance expenses over the years. This plan is based on the projected 3.9-5.5 percent annual increase of water rate.
- A 10-year financed plan serves crucial financial and business policies approved by the Board such as rate setting, financing of fixed assets, cash reserve levels, and investment guidelines.
- Adopted new procurement regulations
- Adopted a more aggressive plan to improve its financial status. In handling uncollectable accounts receivables, WASA sold the bulk sale of $17.1 million of its non-performing account receivable in water and sewer accounts to a private company. Consequently, in FY 1998 it received a one-time $ 10 million increase in revenues. In

addition, WASA settled a long-standing issue with one of its wholesales customers the Loudoun County Sanitation Authority (LCSA), resulting in approximately $19 million of interest income. The Board also implemented a 42 percent retail rate increase in a full year in FY1998.

Operation Practices and Initiatives:

WASA has improved operational approaches in every section; it results in higher and more sustainable performance and water quality. The practices and initiatives in enhancing productivity are reported:

- Comprehensive Master Facilities Plan: This plan, which was taken in by the Board in FY 1998, is a comprehensive 20-year analysis of the system improvement demand. With the 20-year projection of future demands, regulatory requirements, and utility conditions, the plan is a framework for developing WASA's 10-year CIP.
- Capital Improvement Program: With $1.6 billion CIP, WASA plans to rehabilitate all of its capital infrastructures in 10-year time frame. Besides of its financial aspect mentioned, the CIP will support improved productivity and performance within the workforce and customers. To comply with the future strict regulatory and standards, this plan includes the requirement of equipment replacement or addition in its water pumping and storage systems.
- Meter Reading & Operating: Prior to the founding of WASA, this section underperformed industry standards for the ratios of estimated meter reads, the accuracy of meter reads and the cost to read meters. The Authority has urged the

practice of reading meters to all accessible meters. This effort achieves the meter reading up to 99 percent of accounts with accessible meters.

In FY 1999, the ratio of water that is pumped from its treatment plants to the water sale to customers was only 76 percent. One of the main reasons is the accuracy of meter reading. In that year, the Authority approved $34.8 million budget to replace and automate its metering system, which will substantially enhance a more sustainable efficiency in meter reading and billing system in the near future. However, the current change of meter reading practice has improved the accuracy rate of meter reading to 99.9 percent, which is among the best industry standards.

Groundwater is one source of water supply for several buildings in this area. In the past, the Authority didn't meter or bill the amount of water. However, this source of water is drained to the sewer system and eventually to the wastewater treatment plant. In FY1999, the Authority began to inspect the usage of groundwater and install meters to approximately 400 buildings as well as the rail tunnels that have groundwater discharges.

In addition to the productivity improvement practices, WASA adopted several approaches that ensure quality of water supply. One of these practices is.

- Cleaning and Lining Pipes: Like other water utility in the US, WASA encounters with aging pipe in many areas. However, instead of replacing the distribution or main pipe,

WASA chooses to a different approach. It cleans and lines the old pipe with corrosion protection material. While extending the life of pipes, this approach spends much lower investment comparing to pipe replacement. Besides, it minimizes the disturbance caused by open-cut replacement. The result reduces the water pressure loss in the water distribution network and the electricity cost in operating that network.

Human Resource Management:

WASA has an aggressive plan in improving a low efficient water utility to one of the best utility. A great deal of changes happens in financial practices, engineering practices, including an ambitious 10-year CIP. However, these ambitious plans and high expectations need a great deal of cooperation and motivations in its staffs. In FY 1998, it negotiated and executed a single collective bargaining agreement with its unionized employees. To encourage high productivity in the organization, WASA implement a positive reinforcement approach called Gainsharing Program. This program is an innovative approach to evaluate and reward performance of its employees. It provides cash awards, if the workers can reach a certain departmental performance and budgetary target. In the near future, WASA plans to implement maintenance strategies, preventive maintenance program, work order management, and personnel dispatching system.

3.5.4 Summary of Case Study 5

Unlike its predecessor water agency, WASA was established as an independent, multi-jurisdictional water and wastewater authority to improve unstable financial status and

poor operating practices. WASA has authority to set policies, operation practices and rate.

WASA set a long-term master plan that provides analysis of the system improvement demand such as utility conditions, regulatory requirements, future water demand. This master plan grants a direction of policy for WASA to reengineer its organization as well as provides the framework of Capital Improvement Program (CIP) and the requirements of operation improvement. WASA changed radically in many business practices such as increasing rate by 42% in one time, eliminating a practice of estimated meter reading, charging local groundwater users, and lining old pipes. Consequently, the financial stability has been acquired since year one.

Factors contributing to success of this case are the change of organization form. In fact, the practices implemented by WASA are common practices. However, this new form of organization regulates results of these practices to their standard levels. A significant financial improvement has occurred since the beginning of WASA. This fact should lead to an investigation of the causes of financial instability in the past.

3.6 Case Study 6: City of Portland Bureau of Water Works

3.6.1 City Overview

Portland is the largest city in Oregon and one of the principal cities of the Pacific Northwest. The city straddles the Willamette River just above its convergence with the Columbia River. The population of the city is 480,824 (1996 est.)[9], and the greater metropolitan area, which also incorporates the Vancouver, Wash., metropolitan area, as 1,477,895 (1990) residents. The average income state is $ 39768 per year[13].

3.6.2 Water Utility Overview

The Water Bureau is a nonprofit utility. Its water rate is based on only the needs of operation and maintenance costs in the water system, which are protecting the watershed, maintaining facilities and equipment, treating the water to meet standards, and collecting and analyzing water samples. Therefore, all customers must be metered. The total numbers of meters are 169,000, as well as 58 large meters for wholesale customers. Wholesales customers consumed water approximately 40% of annual water demand of the Water Bureau, but that is about 20% of water sales.

The Water system in the Bureau lies on appropriate geography of its perfect location. As shown in Figure 3.8, water flows by gravity through conduits from the Bull Run Headworks to Portland. Powell Butte, acts as the hub of Portland's water supply and distribution system, receives water from Bull Run. Through this Powell Butte, water is transferred to both wholesales customers and the water system of Portland metropolitan.

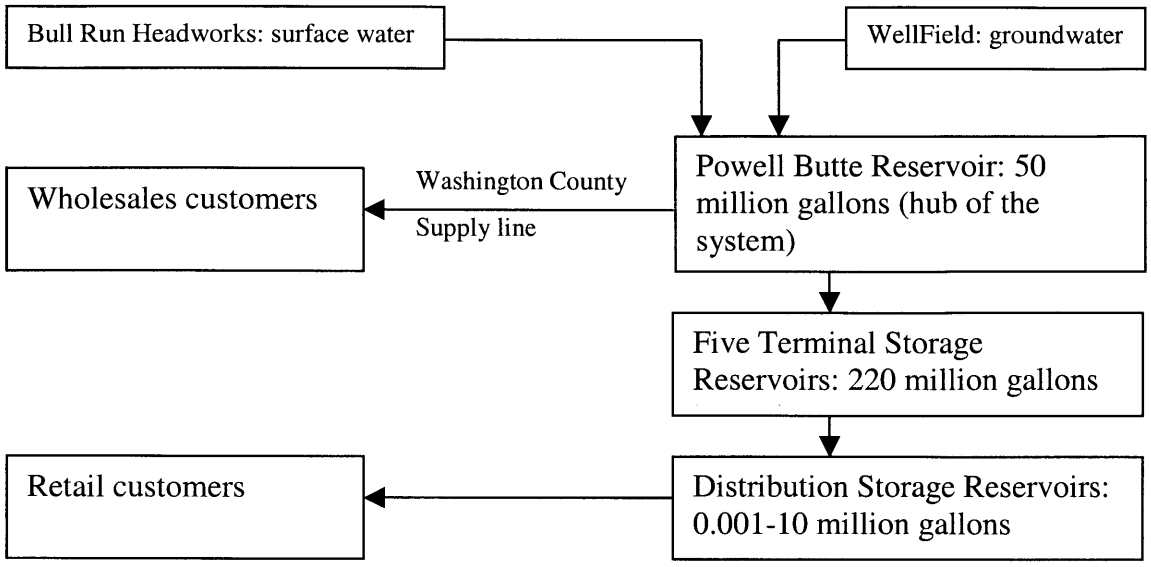

Figure 3.8 Diagram of main water system in the City of Portland Bureau of Water Works (Source: Ref. 2)

3.6.3 Approaches

The Water Bureau role in local communities is based on its philosophy of citizen owned utility. Therefore, the Bureau acts in partnership with its communities it serves, the regulatory agencies, and a group of regional water suppliers to settle plans to supply the arid regulatory demand of the future. Water conservation programs and water shortage program is actively in practice. Watershed protection program with a real time monitoring program is implemented. As a part of the regional communities, the Bureau plays role as a wholesales water provider to 19 customers. One interesting concept of this business relationship is how the wholesales customers have rights to balance with the wholesaler's authority in setting a new policy or rate.

Water Conservation Programs

In 1992, Portland faced summer water shortage, people asked the Water Bureau to set up a measure of water rating to reward water conservation and persuade the customer to use water effectively. The Water Conservation programs target to all segments of its customers i.e. households, business and industry. Some of the programs are as follows:

- Block rates: The Block rates are a procedure to charge a customer with three different rates depends on a number of blocks consumed. The first block is from 1-36 units. The second block is from 37-60 units. The third block is over 61 units. One unit is equal to 100 cubic feet. The water rate of the first, second, and third block are $1.41, 1.62, and $1.62 respectively. Thus, customers who use water more efficient will be charged at lower block rates.
- Enhanced Leak Repair: This program is for low-income households. The City will support participant in leakage inspection at the wall and underground. The program focuses only the low-income families, because this group might not have enough resources to maintain and repair the leakage problem. However, the participants must meet minimum required guidelines of annual income.
- Business, Industry and Government (BIG) water conservation program: The City encourages the business and industry to participate in water conservation program by sponsoring Business for an Environmentally Sustainable Tomorrow (BEST) awards for significant achievement in minimizing waste and conserving energy and resources. Through the BIG program, the City support its customers identify ways to achieve significant water saving. The program includes eliminating single-pass

cooling and installing cooling towers, reusing water, irrigation improvement.

- Water conservation for its wholesales customers: A wholesales proposal contract does not require water conservation program. However, the regional water supply plan has its projected conservation plan and programs in a time frame of 2050.

Wholesales Purveyor Handling

Wholesales customers or purveyors have 40% demand of annual water consumption or 20% of water sales. A long-term contract is necessary for the Water Bureau to gain a sustainable revenue stream. The contract with these 19 wholesales customers is 25 year. However, on the purveyors side they need a guarantee of fair treatment from the Water Bureau either. Consequently, Water Manager Advisory Board of Bull Run Water Users has been formed.

Water Manager Advisory Board acts on behalf of wholesale water purveyors who have a contract with the Water Bureau of the resale of Bull Run water. The responsibility of Board is to give recommendation the City of Portland and other parties relating to the sale of water to wholesale customers outside the City. In general, the recommendations include review of portions of the annual budget and capital improvement program that affect the outside-City purveyors. The Advisory Board has eight members who were elected from service areas as indicated in the Advisory Board By-laws.

Similar to other wholesale water providers, the Water Bureau requires its purveyors to renew the contract several years prior to the completion of contract. For

example, the Water Bureau sent a proposal to City of Tigard to renew its contract 9 years prior to the contract date. Whether City of Tigard sign a renewal contract or not, it provides the City of Portland a period to handle that consequence.

Real Time Watershed Monitoring Program

In 1996, flooding in February caused a rise in turbidity in the Bull Run reservoir. During the early of February, the City had to shut down the Bull Run, and switch its water supply source to groundwater from the Columbia South Shore wellfield. Although the business and residential did not suffer from water shortage, they encouraged the City to have water conservation program to guarantee the availability of water supply. One year later, the Water Bureau improved monitoring programs in Bull Run reservoir, including installed real time turbidity monitoring in the reservoir. This procedure can facilitate operators in control and maintain the water supply quality.

3.6.4 Summary of Case Study 6

The City of Portland Bureau of Water Works is a nonprofit utility that provides 40% of its water production to wholesale customers. An abrupt fluctuation in revenue stream can occur, if a few wholesale customers stop buying its water. In addition, during the past few years, flooding in February caused a rise in turbidity in the Bull Run reservoir. The Bureau needs a procedure to maintain a quality of water supply.

The City set a long-term contract with wholesale customers, citywide water conservation programs, and a real time watershed-monitoring program to provide

reliability in both performance and financial status. The long-term contracts between the City and its outside-city wholesale customers last 25 years. The Water Bureau allows its wholesale customers to participate in policy making through Water Managers Advisory Board of Bull Run Water User. This fair treatment practice creates a balance of power between the Bureau and its wholesale customers. A real time watershed-monitoring program can signal in a rise of turbidity in water supply.

Factors contributing to success in this case are its commitment to fair treatment and its nonprofit concept. As well as, perfect location of water utility provides low operating cost of water supply. These factors lead wholesale customers to admire the services and choose to extend long-term contracts with the Bureau.

4 Discussion

All water utilities require extensive capital investment[17]. Several practices in the case studies represented how the authorities with different settings strategically maximize the cost-benefit of their investment through different tools. The characteristics of these authorities can be interpreted by their choice of practices. This part will discuss some observations from the case studies through the following practices implemented by these water utilities.

4.1 Water Resource Planning and Water Conservation Program

4.2 Watershed Protection Program

4.3 Initiative Concept

4.4 Wholesale Contract

4.5 Capital Improvement Program

4.1 Water Resource Planning and Water Conservation Programs

Water resource planning and water conservation programs serve water utilities for many purposes such as mitigating the water shortage or postponing the expansion of water production capacity. In this research, LADWP, SDCWA, SPU and Portland Bureau of Water Work use this practice with different necessity.

The southern and western regions of the US have an issue of water scarcity. In general, this region is arid. The growth of population and the standard of living result in high water demand. During 1987-1992, a severe drought cycle has occurred in California. MWD the largest wholesale water supplier in California ordered all water agencies, its

customers, to cut water usage substantially. Consequently, the multi-billion economies in the Cities like Los Angeles and San Diego faced threat from this drought. LADWP has prepared for drought for many years, so the impact of drought was manageable. San Diego suffered by this drought greatly, because MWD was almost the only water source. The situation during that drought was simply a crisis in San Diego, because San Diego had never prepared for that severe drought.

The City of Los Angeles has been proactive to acquire alternative water sources since 1913 that it firstly constructed first aqueduct of Los Angeles Aqueduct (LAA) to convey water from the upstate Owen River. Then, in 1940 the City constructed a second aqueduct of LAA. Recently water source from LAA is about half of water consumption. Later, in 1960 the City started to recycle water. In the history of MWD's establishment, one of LADWP management team was a key player to outline the route of MWD's aqueduct[4].

On the other hand, the management boards in SDCWA have just shifted their paradigm greatly since 1991 drought; water has become unquestionable fuel of their fast-paced economies. Interestingly, the scarcity in California has been reported for years, and drought cycle is predictable. Why did these decision makers need a crisis to start a preventive procedure?

With the change of mindset, both utilities learn that they cannot rely on a sole imported water source like MWD to acquire economic stability. Therefore, they implemented the concept of water source portfolio.

The portfolio of imported water sources in San Diego County is as follows.

- Source 1: Metropolitan Water District of Southern California (MWD)
- Source 2: Water exchange program between MWD and the San Diego County's Imperial Irrigation Department.
- Source 3: Helix Water District
- Source 4: Sacramento-San Joaquin Bay-Delta estuary
- Source 5: Local water sources

While, the portfolio of water source in LADWP that has settled for many year earlier is as follows.

- Source 1: Los Angeles Aqueduct (LAA)
- Source 2: Metropolitan Water District of Southern California
- Source 3: Groundwater
- Source 4: Reclaimed water

The cost of water from each source is different. Therefore, LADWP has tried to maximize the ratio of water source from LAA, because of its cheapest unit price among its major three water sources. For the sake of mitigating the environmental impact in Owen Lake, LADWP has been obligated to reduce the ratio of water from LAA source

since 2001. LADWP reduce the usage to the highest level that is allowed. Still, this practice is based on the concept of maximizing the ratio of this source. In addition, LADWP might consider that LAA source is no longer a reliable source.

The commitment to sustain economic growth is a main motive of the water conservation program, rather than the concern of environment, even though that could threaten to environment of the region. Interestingly, with the policies that pro rapid economic growth, availability of water resource in this region might not be sufficient to the challenges facing water demand in the 21st century. Eventually the water usage will reach a limit of water resource, so this policy could not provide a long-term sustainable growth of economy either. Perhaps, the federal government should intervene by steering the growth of water consumption in the states with water shortage issues like California.

Unlike LADWP and San Diego County, the Seattle Public Utility and Portland Bureau of Water Works have sufficient water resource. In fact, they have enough excess water to export approximately 40 percent to outside-city wholesale customers.

However, after they have experienced a couple of tentative water shortage scenarios during the past decade and a trend of national water conservation, citizens encouraged their authorities to have a water conservation program. On the authority side, it is a low-cost measure to postpone a need of investment in the water capacity expansions. On customer side, this program gives incentives to a customer who consumes

water wisely. Consequently, the water conservation programs in SPU and Portland are from less severe water shortage situation, but from similar cooperation of customers.

4.2 Watershed Protection Program: Invest to not invest in NYW

Water Protection Program often needs a partnership beyond one jurisdiction. The case study of NYW, for example, requires a partnership New York City, New York State, and 79 municipalities lie in watershed areas. The benefits of watershed protection program are crucial especially for the water utility depends on only these remote sources of water like NYW. The sustainable condition of watershed area provides both future water supply quality and quantity including best rate structure of water. NYW constructed 125-mile long Aqueducts to transport water from Catskill and Delaware systems in 1917 and 1936.

Before the usage of Catskill and Delaware system in 1900s, New York City encountered one of its worst epidemics in 1832, resulting in population sharp drop by death and migration, and leading to its economy recession.[18] After that health crisis, NYC went out to use Croton watershed system as its water source. Interestingly, nearly two hundred years later, a good watershed is still the only best idea of present decision makers.

Nowadays the importance of watershed condition is crucial, because if the quality of these watersheds is lower than a certain point, the USEPA will use the Surface Water Filtration Rule to require NYW to filter that water before pumping into its distribution systems. Currently the USEPA has obligated NYW to construct a filtration facility for the

Croton system. Croton system supplies only 10% of the City's water consumption. NYW projected more than 900 million for the Croton filtration facility. Therefore, if NYW has to construct filtration facilities for another 90 % of its water from Catskill and Delaware systems, it certainly requires much higher investment.

NYW uses this watershed protection program to negotiate with the USEPA to postpone this massive investment. NYW projects approximately $600 million in the Watershed Protection Program. This includes $310 million for the economic-environmental partnership program with the upstate communities and $250 million for the land acquisition. After this agreement issued on January 21, 1997, three months later the USEPA renewed a five-year filtration avoidance determination for both Catskill and Delaware water supply systems.

In general, watershed protection programs function in two ways, one is to enhance environmental awareness in the area and two is to limit the activities having potential environmental deterioration in the area. All activities in the area need to comply with the program. In case of NYW, the Watershed Memorandum of Agreement promotes and enforces both purposes through its three components: Land Acquisition Program, New Watershed Regulations, and Watershed Protection and Partnership Programs. These comprehensive programs manipulate direction of economic development in 79 municipalities. Any development in the area from public or private sectors need to not only comply with the regulations of State, Federal government, or the USEPA, but also conform with the regulation of this Agreement. The strict regulations in the area are

traded of with healthy financial status and environment of communities in the area over a long term with this direct and indirect budget in the programs in return.

Interestingly, this Agreement provides room for NYW to minimize its spending. For example, the Land Acquisition Program has projected budget of $ 250 million. However, this program has no requirement to buy a specific target of acreage. In addition, this program gives a choice of two acquisition approaches—the land outright purchase and land conservation easement. Consequently, NYW can choose either low cost method of land conservation easement or high spending method of outright purchase. The outright land purchase gives NYW a direct control over watershed area and minimizes its spending in the long run, if the EPA requires NYW to build filtration facility for Catskill and Delaware water supplies in the future. The right decision requires a commitment of NYW to this long-term sustainable watershed protection program.

Ninety percents of NYC water supplies are from Catskill and Delaware system. Therefore, it is a question if a watershed protection program alone is reliable enough to bet with the welfare of 7.4 million people in New York City. San Diego County has learned how important the reliability of water system is to their economy since the 1991 drought. Therefore, they have invested to improve the reliability of water quality and quantity in water system. Although the epidemics like 1832 will probably not occur, the reliability of NYC's water system should still be assessed. The risk of New Yorkers is 90% of their water supply rely on the efficiency of the Memorandum of Agreement in the upstate watershed areas and the commitment of their politicians to this Memorandum.

Currently, the water rate of NYC is among the lowest in the US. Politicians perhaps reluctant to invest in large filtration projects for Catskill and Delaware systems, because that eventually leads to an increase in water rates and tax. From a political point of view, anti-rate increase is expected. However, it results in a more risky approach. Perhaps, an innovative project delivery system discussed in the following part can be a good solution to achieve both reliability of water system and appropriate level of rates. In addition, a study of cost effectiveness and risk assessment in the watershed protection program of NYW is required.

4.3 Initiative Concept: WASA and SPU

Initiatives in water industry have not often been adopted, because of no high competition in this industry. However, other factors such as crisis can motivate water utility to open to a better practice. WASA is a good example of this claim. It was created to replace the predecessor agency, the District of Columbia Water and Sewer Utility Administration of the Department of Public Works (WASUA) in 1996. Unlike WASUA, WASA is an independent, multi-jurisdictional water and wastewater authority. It has introduced many initiatives in the short-term and long-term plans to enhance the productivity and net income of its organization. However, the initiatives of WASA are quite common practices. SPU and the City of Portland, which are municipal department like WASUA, do not require an organization of a regional independent authority to initiate the similar practices. Therefore, the motivation of changing form of organization is interesting.

The achievement of WASA has happened after its major reorganization. WASA significantly reengineers its organization that had poor performance through bold measures in policy level, decision-making level, and operating level. WASA uses a new Comprehensive 20-year Master Facility Plan as its framework to achieve its significant improvement. However, this rapid and radical change can be adopted only because this water utility was previously in an unstable financial status. WASA uses its own crisis to facilitate its internal self-assessment program.

For example, WASA increased water rate in one time by 42% in FY1998, reduced the practice of estimated meter reading significantly, and started to switch the meter type with a short decision process; these are difficult to happen in a normal situation. During this fast paced improvement and harsh situation, WASA dropped an alternative of selling or private partnership of the Blue Plain wastewater treatment plant—the largest wastewater treatment plant in the world. Through its extensive study, WASA claimed that the improvement gained from its ongoing efficient internal self-assessment process provides an equivalent result to the private partnership. Details of this comparison study are not provided. However, the comparison criteria of this study should be interesting. After the net income reached peak in 1998, the net income of WASA in 2000 is now lower than last year. Meanwhile the water sold/water pumped ratio is lower than that of 1996. One can argue the accuracy of this ratio in 1996. It simply shows the poor conditions of distribution system in its service area. In addition, significant improvement within the first year of WASA should lead to an investigation of real causes of financial failure in the former management team.

Seattle Public Utility (SPU) is a good example of efficient organization with initiatives. This efficiency of SPU acquires from its commitment to a comprehensive long term strategic business planning that promotes cost effectiveness and openness to innovation and technology. Interestingly, the organization of SPU is a conventional municipal department. This reveals the efficiency of water utility can be achieved from the traditional structure of organization.

SPU sells approximately 40% of its water production to wholesales customers, and the ratio is growing rapidly. A fluctuation of water turbidity in the Tolt River creates a periodical unavailability of the river water. Consequently, the possibility of capacity expansion and the stability of its revenue stream are difficult to achieve. The Tolt River project minimizes these problems, while supporting the ability of SPU in setting a long-term plan for water production and water sales.

In general, this Design Build Operate (DBO) approach can reduce a long term operating and maintenance cost by 10-15% comparing to Design Bid Build (DBB)[19] . In addition, it encourages bidders to introduce better technologies that result in higher capacity but cheaper operating cost. SPU uses Design Build Operate as a delivery method of the Tolt Water Treatment Plant. SPU enhanced the efficiency of this approach by using a traditional DBB studied by another group of consulting firm as a benchmark to control the scopes and budget of DBO approach. With this benchmark, SPU can practically compare the proposed cost structures of construction, equipment, operation, and maintenance. This practice resulted in $70 million project cost saving from the

benchmark price of 156 million in Tolt Water Treatment Plant Project, including a priceless high reliability water system. Perhaps, NYW can also find this approach appropriated, if it has to build the large filtration facility for Catskill and Delaware water supply.

4.4 Wholesale Contract: SPU and Portland Bureau of Water Works

Unlike the utilities in the west and south, Portland Bureau of Waterworks and Seattle Public Utilities (SPU) have sufficient water resources from surface water and groundwater. Portland Bureau of Water Works and SPU have a 25 year and 30 year contract respectively for their wholesale customers. In addition, they require the wholesales customers to renew contract many years—9 years and 15 years respectively—prior to the last day of contract. This approach is to maintain their long term sustainable revenue stream.

Unlike MWD in California, SPU and Portland Bureau as water suppliers have customer oriented point of view, because their customers have choices. In East and South County, the customers of SPU can choose between SPU and Tacoma Water Utility. In addition, its customers develop alternative water source such as groundwater. Therefore, the concern of revenue fluctuation is logical. Through the wholesale customers contracts, SPU and Portland Bureau clearly compare the projected cost if their customers build their own facilities with the cost of buying water from them.

Portland bureau positions itself differently from SPU in terms of customer engagement. As mentioned in the case study, the wholesale customers of Portland Bureau can participate in a policy development process that could affect their contracts and water rate. This concept creates a balance of power between the water provider like Portland Bureau and its customers. Besides, Portland Bureau provides water to about one quarter of populations in Oregon and is a member of a Regional Water Providers Consortium that provides a regional water supply strategy and policy for the future. Portland Bureau itself is a nonprofit utility. Therefore, these settings and mindset can explain why Portland Bureau promotes fairness in regional public service rather than makes profits from those wholesale contracts.

4.5 Capital Improvement Program: San Diego County Water Authority

The Capital Improvement Program (CIP) is necessary for water utilities, because the life cycle of components in the utility end at a different period of time. Therefore, the preventive maintenance program, replacement program in CIP can guarantee the quality of water supply and reliability of the water system. However, CIP is a high budget plan. The Anti-tax and water rate increase in politicians and citizens are likely to object the plan. For the San Diego County Water Authority, the interesting part is not only the CIP itself, but how the Authority struggle to earn approval of CIP from politicians and citizens.

After failing repeatedly to receive support from the City Council to raise water rate, the water Authority has no funding to support the Capital Improvement Program.

Therefore, the City changed strategy of gaining support from citizens by addressing the current and future needs of water storage, treatment and delivery needs including the present deteriorated condition of water distribution system. Through the so-called public advisory group, the City can educate and finally earn support from the publics. The City's strategy in this campaign should be an example for other cities to receive approval from public, even though each utility has different conditions.

San Diego County achieved the CIP approval after the drought crisis. This scenario leads to the question of if preventive procedures in other practices are currently disapproved by politicians and citizens. Will that be a risk for anther crisis?

5 Summary and Further Studies

Water industry in the US has no competition; hence, it has little incentive to significantly improve its efficiency. However, in this research necessities such as financial crisis in WASA, water shortage in SDCWA, new regulations in NYW, high ratio of wholesale customers in Portland Water Bureau, or threat of high turbid water source in SPU motivate these water utilities to substantially improve performance through enhanced management practices. Some case studies show insufficient preventive procedures that led these water utilities to the urgent improvements. Factors contributing to success include citizen support in SDCWA, the support of the New York State in NYW, long-term planned resource management in LADWP, fair treatment in Portland Bureau, and efficient strategic planning in SPU.

These examples provide tentative practices that might serve as models for other utilities to follow. However, further studies should continue to investigate their success of these management practices over longer period. In addition, the factors contributing to success in these utilities should be examined. Understanding these settings could help water utilities to successfully apply the practices in the future.

In addition, efficient tools and indicators for evaluating the standard of water utility and improving transparency of this industry should be adopted. Decision makers could use this transparency to develop better practices. As a result, these higher efficient utilities will contribute public welfare to society as a whole.

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